Laboratory Evaluation of HMA and WMA in BC Layer

Revansiddappa M[1] Dr.Kiran Kumar[2] Manjunath. S[3] Arvind C[4] Suraj Pokalwar[5]
[1,3,5]Assistant Professor [2]Professor [4]Lecturer
[1,2,3,4,5]Department of Civil Engineering
[1,5]LAEC, Bidar [2,3]SKSJIT, Bangalore [4]GPT, Bijapur

Abstract— Warm mix asphalt (WMA) is a relatively new and emerging technology for the asphalt Industry. The goal of WMA is to produce mixtures with similar strength, durability, and performance characteristics as HMA using substantially reduced production temperatures. It offers potential construction and environmental advantages over traditional hot mix asphalt (HMA). Several new processes have been developed to reduce the mixing and compaction temperature of hot mix asphalt without scarifying the quality of resulting pavement. Research in the laboratory was carried out to determine if the addition of Sasobit (WMA) has potential to increase the stability comparison with hot mix asphalt (HMA). For the present study, Sasobit has been tried as additive to achieve the higher stability at low temperatures. The addition of Sasobit to bituminous mix has been evaluated by testing their laboratory performances as compared to HMA mixes with different binders such as VG-10, VG-30 and CRMB-55. Marshall Mix properties namely stability, flow, bulk density, air voids, VFB and VMA was evaluated for both HMA and WMA. Indirect tensile test to evaluate the volume of air voids and Tensile strength ratio at different blows as 40, 60 and 75 for both conditioned and unconditioned specimens prepared by HMA and WMA with different grade binders. And the present research, it has been seen that WMA technology reduces 20percent temperature as compared with HMA technology .And also been seen that, there are changes in volume of air voids and tensile strength ratio for both conditioned and unconditioned specimens.

Key words: hot mix asphalt, warm mix asphalt, Sasobit

I. INTRODUCTION

Warm Mix Asphalt is comparatively new in India in which an additive is mixed with hot asphalt mixes in desired proportion so as to lower down the hot mix temperature from 160^{0}C to 135^{0}C- 140^{0}C for the preparation of workable mix laying. The goal with WMA is to produce mixtures with similar strength, durability and performance characteristics as HMA using substantially reduce production temperature.

Warm Mix Asphalt is a new technology which was introduced in 1990's in Europe. The earliest WMA process developed in Europe were based on either waxes or foamed asphalt. Waxes are added to the binder to reduce its viscosity and improve lubrication. A large number of new processes and products have become available that have the capacity of reducing the temperature at which hot mix asphalt is mixed and compacted without comprising the performance of the pavement. These new products can reduce the production temperature by as much as 20 percent. North American Asphalt mixes are generally heated at 149^{0}C or greater depending on the type of the binder used; mixes produced with these new products are being produced at a temperature of about 121^{0}C or lower. Lower plant mixing temperatures means fuel lost saving to the contractor and findings have shown that lower plant temperature can lead to a 30 percent reduction in fuel energy consumption [1]. Lower temperature also means that any emissions, either visible or non-visible may contribute to health, odor problems, or greenhouse gas emission will also be reduced [2]. The decrease in emission represents a significant cost savings, considering that 30-50% of overhead costs at an asphalt plant can be attributed to emission control [3]. Lower emissions may allow asphalt plants to be suited in non-attainment areas, where there are strict air pollution regulations. There is another potential advantage in that oxidative hardening of the asphalt will be minimized with the lower operating temperatures and this may result in changes in pavement performance such as reduced thermal cracking, block cracking, and preventing the mix to be tender when placed. Three techniques have been used to improve the workability of an asphalt mixes at lower temperature which includes Aspha-min, Sasobit and Evotherm. This report presents an evaluation of one such additive in particular, branded sasobit, which is a product of Sasol wax.

Aspha-min and Advera are Synthetic Zeolites. Zeolites are minerals that have approximately 20 percent by weight of water trapped in their porous structure. Depending upon heating to approximately 85^{0}C, the water is released, and when this is done in the presence of asphalt binder, foamed asphalt is produced. Synthetic Zeolite additives are typically added at the plant. To be effective, it is critical that the additive is quickly encapsulated in the asphalt binder and not lost in the exhaust air stream of the plant. The first chemical additive process used in the United States, it was the Evotherm process developed by Mead Westvaco and was introduced in 2005. The active ingredients in Evotherm are the chemical additives that reportedly improve coating, workability and adhesion at lower temperature. The emulsion contains approximately70 percent asphalt binder by weight. The water in the emulsion vaporizes when mixed with hot aggregates leaving the residual asphalt and chemical additives.

A. Sasobit as an Additive

Sasobit is described as an "Asphalt Flow Improver", both during lay down operations, due to its ability to lower the viscosity of the asphalt binder. This decrease in viscosity allows working temperature to be decreased by 18-54^{0}C. At temperature below its melting point, Sasobit reportedly forms a crystalline network structure in the binder that leads to the added stability. During, the production of HMA, Sasol recommends that Sasobit is added at a rate of 0.8% or more by mass of the binder but not exceeding 3%.

II. LITERATURE REVIEW

1) I.R Arya, V.K. Jaitly and M.C.Hartt in their paper" Role of mixing and compaction temperatures on the properties of bituminous mixes"[5] studied the effect of different combination of mixing and compacting temperatures on properties of bituminous mix such as

bulk density, air voids filled with bitumen and stability. Hence they concluded the range for mixing and also for compacting temperature for bituminous mixture. This range of mixing and compaction temperatures are decided based on several combination of mixing and compacting temperature which represents different viscosity values.

In this study the materials used includes aggregates and paving bitumen. The paving bitumen used were 60/70 and 30/40. He made conclusion that bulk density values can be obtained for each mixing temperature 135°c,149°c,163°c,177°c and 190°c and compacting temperatures of 121°c,135°c,149°c,163°c, and 177°c respectively. It was found that the bulk density values of 98 to 100 % were obtained at selective compacting temperature. In case of air voids, it increased at each mixing temperature with decrease in compacting temperature.

From this study it was observed that for every mixing temperature there is a definite compacting temperature. For every mixing temperature, if the compacting temperature is reduced the voids filled with bitumen will also reduce. For each mixing temperature there is one compacting temperature which satisfies the stability value. Finally he concluded that the air voids should be 3% instead of 4% in design and compacting temperature plays an important role in controlling the density and other properties of bituminous mixes. Temperature difference at 140°c gives best mix properties.

2) Chandra. K. Akisetty, soon-jae Lee, seiji. N. Amirkhanian in their paper "Effect of compaction temperature on volumetric properties of rubberized mixes containing warm mix additive"[6] studied the effects of compaction temperature on volumetric properties. This study investigated to study the effects of compaction temperature on rubberized mixes containing the warm mix additives using super pave gyratory compactor. For this four different super pave mix design were selected along with two asphalt binders and two aggregate sources were selected. Specimens were fabricated for all four types of super pave design with different percentages of binder content so has to determine optimum binder contents. Warm rubberized mixes were produced using two of the available processes. A total of 192 specimens (4 mix types: control mix, rubberized mix, warm rubberized mix 1, and warm rubberized mix 2*2 aggregate sources compaction temperatures: 97,116,135, and 154°c*6 repetitions) were fabricated using super pave gyratory compactor. Volumetric properties of the specimens were evaluated. The results showed that the warm mix processes were effective to improve the volumetric properties of rubberized mixes at a certain range of compaction temperatures.
3) Dab sosnorske in his paper "Determination of Proper Mixing and Compaction Temperature of Laboratory Fabricated Asphalt Concrete Specimens"[7] studied to evaluate the differences in Mechanical properties between the samples prepared using constant temperature and viscosity based temperature by proper selection technique. Based on this he made recommendations on mixing and compacting temperature for bituminous mixture. In this study viscosity of 170°C for mixing and 280°C for compaction was considered. In constant temperature method 135°C ±30°C for mixing and 124°C ±30°C for compaction was taken for each specimens prepared various physical properties were assessed like Bulk density, Maximum specific gravity, air void, Hveem stability, Index of retained strength and Resilient modulus were evaluated. The specimens were prepared with Traditional method and then by viscosity based technique.

He made a conclusion that there was a narrow range of temperature. At the same time, there was very little difference between the two temperature techniques for these results obtained. He recommended that the bituminous materials should adopt viscosity based temperature selection and to select proper temperature and using same type of materials or gradation rather than using different types of materials and improve the ODOT Bituminous lab process.
4) Jenkins, K,J., de Groot, Van de Ven, in his paper "Half warm Foamed Bitumen treatment, came up with the new technique, investigated the concept and benefits of preheating aggregates to temperature above ambient level and below 212°F(100°C) before adding foamed bitumen. The results showed a good practical coating, mix cohesion, tensile strength and compaction.

III. MATERIALS AND METHODS

A. Materials Used

For the present study, aggregates, different types of bitumen's as VG-10, VG-30 and CRMB-55 for hot mix asphalt and bitumen types with sasobit as an additive used for warm mix asphalt

B. Aggregates

Aggregates have good compressive strength; along with this they provide good interlocking facility with good permeability. Aggregates mainly consist of both coarse and fine aggregates. Coarse aggregates of 19mm to 2.36mm and fine aggregates of 2.36mm to 75µ were used. Basic tests of conventional and recycled aggregates were carried out and the results are as presented below.

Properties	Virgin	Permissible Limit (As per MORTH)
Impact Value AIV) %	15.2	27 max
Crushing Value, %	19.2	24 max
Absorption Value, %	31.9	35 max
Specific Gravity	2.56	2.5-3.0 max
Water Absorption	0.5	2.0 max
Combined Index, %	19.82	30 max

Table 3.1 Properties of Virgin Aggregates

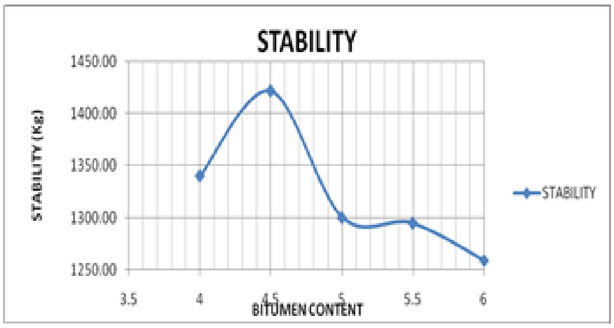
C. Bitumen

The bitumen samples used in this study are VG-10, VG-30, and CRMB-55. The engineering tests were conducted and the results are presented below

Properties	VG-10	VG-30	CRMB-55
Penetration at 25^0C, 5sec	83	65	57
Softening Point ^{0}C	43.2	47	56
Flash Point, ^{0}C	258	282	294
Ductility at 25^0C	104	99	92
Specific Gravity	1.02	0.995	-

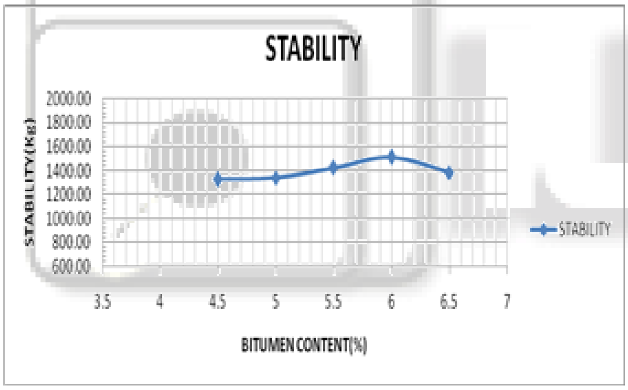
IV. EXPERIMENTAL PROGRAMME

A. Marshall Stability for VG-10



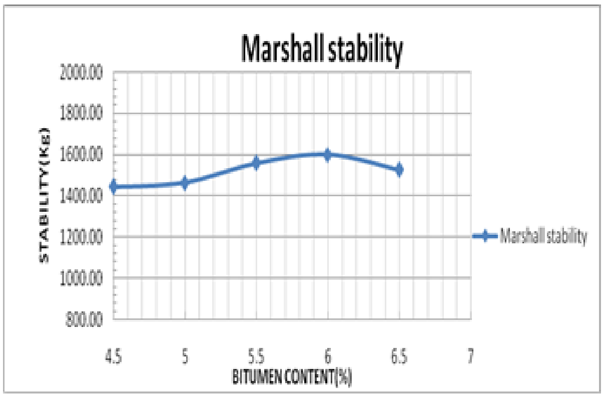
Stability value for VG-10 is 4.6

B. Marshall Stability for VG-30



Stability value for VG-30 is 6

C. Marshall Stability for CRMB-55



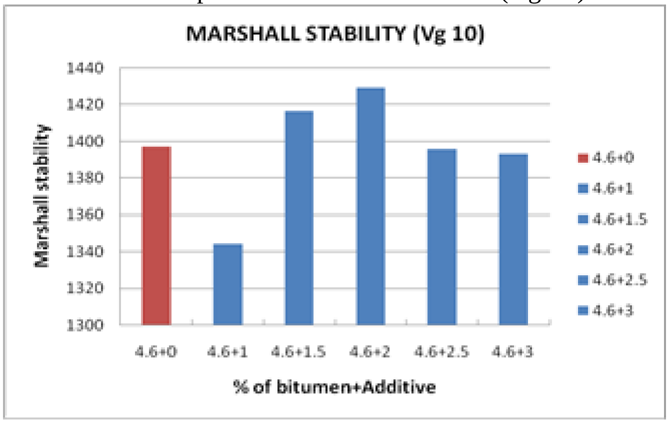
Stability value for CRMB-55 is 6

V. RESULTS

A. Comparison of Bituminous Mix Properties

% of bitumen + Additive	Marshall stability
4.6 + 0	1397.19
4.6 + 1	1344.26
4.6 + 1.5	1416.3
4.6 + 2	1429
4.6 + 2.5	1395.8
4.6 + 3	1393.03

Table: Comparison of HMA and WMA (Vg-10)

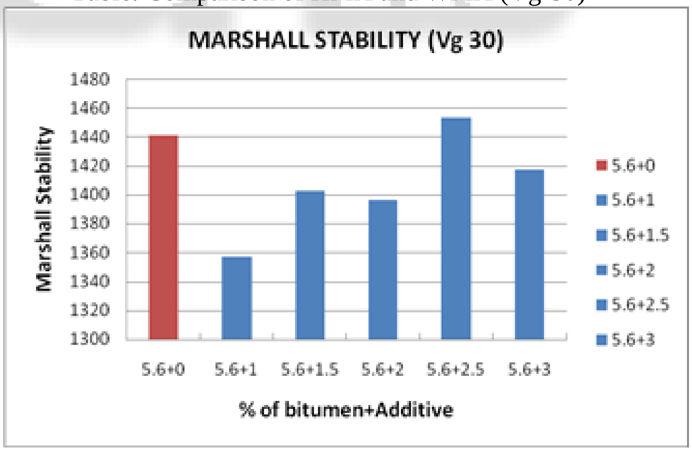


Graph: showing Variation of Stability of HMA and WMA (VG-10)

Graph shows the highest Stability for WMA as compared to HMA at bitumen content 4.6% and Additive of 2% and showing the lowest Stability at bitumen content 4.6% and Additive of 1% for grade VG-10.

% of bitumen + additive	Marshall stability
5.6 + 0	1441.38
5.6 + 1	1357
5.6 + 1.5	1402.4
5.6 + 2	1396.4
5.6 + 2.5	1453.3
5.6 + 3	1417

Table: Comparison of HMA and WMA (Vg-30)

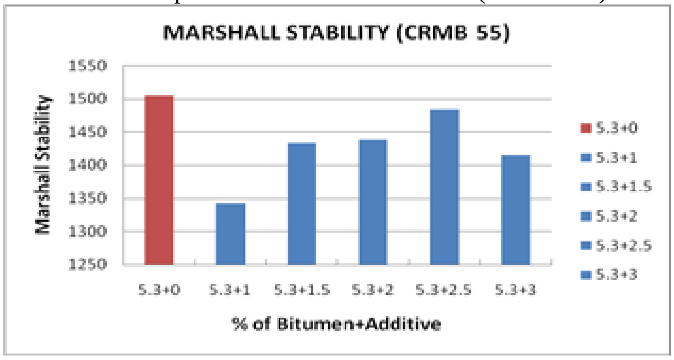


Graph: showing variation of stability of HMA and WMA (VG-30)

Graph showing the highest Stability for WMA as compared to HMA at Optimum Bitumen content (OBC) 5.6% and Additive of 2.5% and lowest stability at OBC 5.6% and Additive of 1% for Grade VG-30.

% of bitumen + additive	Marshall stability
5.3 + 0	1504.99
5.3 + 1	1342.5
5.3 + 1.5	1433.3
5.3 + 2	1437.2
5.3 + 2.5	1483.3
5.3 + 3	1414.2

Table: Comparison of WMA and HMA (CRMB-55)

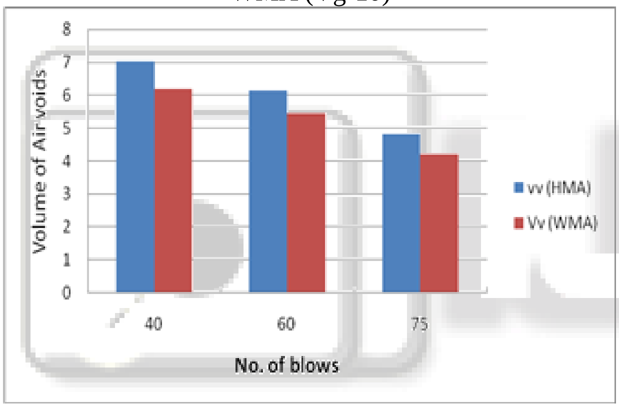


Graph: showing variation of stability of HMA and WMA (CRMB-55)

Graph showing the highest Stability for WMA as compared to HMA at Optimum Bitumen content (OBC) 5.3% and Additive of 2.5% and lowest stability at OBC 5.3% and Additive of 1% for Grade CRMB-55.

Bitumen	No. of blows	Vv (HMA)	Vv (WMA)
4.6	40	7.03	6.2
	60	6.125	5.45
	75	4.82	4.21

Table: Comparison of voids varying blows for HMA and WMA (Vg-10)

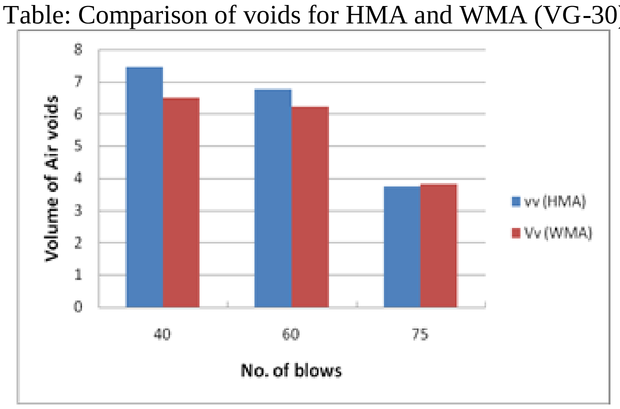


Graph: Variation of voids for HMA and WMA (VG-10)

Graph showing the decrease in the volume of voids with increasing the number of blows for both HMA and WMA for VG-10. Volume of voids for HMA is more as compared to that of WMA for all 40, 60 and 75 blows.

Bitumen	No. of blows	Vv (HMA)	Vv (WMA)
5.6	40	7.46	6.51
	60	6.75	6.21
	75	3.75	3.82

Table: Comparison of voids for HMA and WMA (VG-30)



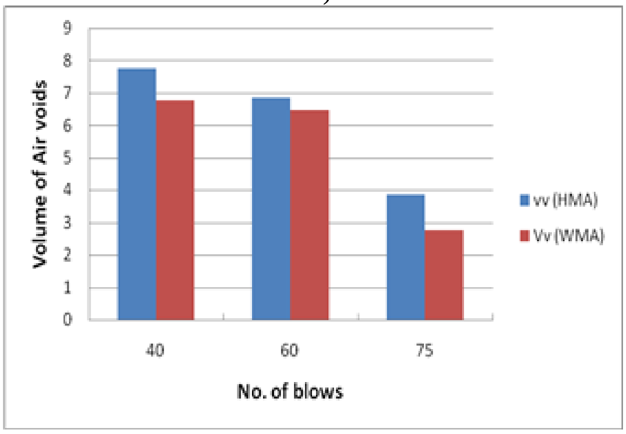
Graph: showing variation of voids for HMA and WMA (VG-30)

Graph showing the decrease in the volume of voids with increasing the number of blows for both HMA and WMA for VG-30.

Volume of voids for HMA is more as compared to WMA at 40 and 60 blows but at 75 blows volume of voids slightly more in case of WMA to that of HMA.

Bitumen	No. of blows	Vv (HMA)	Vv (WMA)
5.3	40	7.76	6.76
	60	6.84	6.48
	75	3.87	2.77

Table: Comparison of voids for HMA and WMA (CRMB-55)



GRAPH: showing variation for voids for HMA and WMA (CRMB-55)

Graph showing the decrease in the volume of voids with increasing the number of blows for both HMA and WMA for CRMB-55.

Volume of voids for HMA is more as compared to that of WMA for all 40, 60 and 75 blows.

VI. Discussion and Conclusion

The laboratory investigations carried out on BC Grade-II mix for Water sensitivity test to determine the volume of air voids by varying number of blows and Indirect Tensile Strength to determine the TSR for both HMA and WMA are summarized as follows.

1) The basic tests conducted on conventional and recycled aggregates showed that they satisfied all the requirements as per MORT&H, IV revision.
2) Warm mix asphalt mix prepared using sasobit as an additive shows higher stability value at 2% of additive for VG-10, and 2.5% for binders VG=30 and CRMB-55.
3) Warm mix asphalt for different binders as VG-10, VG-30 shows 2.2% and 0.8% higher stability than the BC grade II virgin mix
4) The volume of air voids for WMA and HMA mix for different binders as VG-10, VG-30 and CRMB-55 decreases with increase in the number of blows.
5) The volume of air voids for WMA for different binders as VG-10, VG-30 and CRMB-55 lesser as compared to that of HMA mix.
6) Indirect tensile test of WMA mix prepared, shows higher tensile strength at different blows as 40, 60 and 75 when compared to that of HMA mix.
7) The increase in indirect tensile strength ratio is observed for the mixes prepared using CRMB-55

both for HMA and WMA mix. This result in higher resistance to the damage associated with moisture.

8) The WMA may be replaced by HMA, to bring the higher stability and reduces the environmental pollution.

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